cano. Such water must undoubtedly have been ejected hot, and must have held in solution a large percentage of the soluble solids—rock-salt, quartz, feldspar, etc. The water of these cloud particles would soon disappear in the upper air by evaporation, and their solid contents would be left floating as an impalpable powder of particles, whose size could be determined by optical methods.

On the other hand it is also important to remark that it is not unlikely that the famous red sunsets of 1883–4 were due to simple selective reflection from solid dust fragments, or to diffraction between dust particles, or to refraction and dispersion through transparent crystals. To me it seems most likely that another optical process was involved, and that these sunsets were produced essentially by a combination of two phenomena, namely (1) the selective absorption of the sunlight by the atmospheric aqueous vapor, a dense layer of which allows the red rays only to be transmitted, and (2) the diffraction of the red rays thus produced, as they passed between minute spheres of water or minute particles of dust. The diffraction effect thus produced depends on the size of these spheres or particles, and this determines the extent and duration of the sunset glow at any one place, as well as the limits of its geographical distribution. The red tint was produced by the absorptions. The particles of dust could not produce these beautiful diffraction phenomena unless they had great uniformity in their size and distribution. It is most likely that both the colored suns, the sunset sky colors, and the successive afterglows, as also the Bishop's ring of 15° to 25° radius, were due to the same minute vapor particles or so-called "vapor dust," and that mineral dust played only a minor part in their production.

Whether the particles were dust or vapor we shall obtain the same results as to their dimensions by a computation based on the diffraction formula first given by Fraunhofer, according to which particles that have an average diameter of 0.000153 Paris inch, or 0.000145 English inch, or 0.00368 millimeter, would fairly well explain the red sunset phenomena observed by me from August to November, 1885, at Washington; particles whose average diameter is 0.000101 Paris inch, or 0.000095 English inch or 0.00241 millimeter, would explain the phenomena of Bishop's ring, as observed by me on the same dates.

The fact that the red sunset phenomena continued for two years longer, my last observation being in February, 1887, and that they are frequently visible now all over the globe as a pink spot in the west after sunset, in mid-ocean as well as in the center of a continent, and that the spot never was a rare phenomenon, increases the probability that they are due to moisture rather than to mineral dust. (See American Meteorological Journal, April, 1889, Volume V, pages 529–544.)

An afterglow of a beautiful pink tint was frequently observed by myself in tropical regions during the cruise of the *Pensacola*, October, 1889, to May, 1890, on the United States scientific expedition to the west coast of Africa.—*C. A.*

THE CONVECTION THEORY OF WHIRLWINDS.

It is well known that Professor Espy, in developing his theory of the formation of tornadoes, and also, we believe, Doctor Mitchell of North Carolina have both of them quoted a few definite cases in which the whirl in an ascending column of flame and smoke over a fire in forest or cane brake developed into a cloud with a moving, whirling column, which, during the course of a half hour, became a rainstorm, a tornado, or thunderstorm, depending upon the condition of the surrounding atmosphere. Many others will perhaps agree with the Editor in having themselves seen a rising mass of air become at first hazy and then cloudy, and eventually turn into a rainstorm before disappearing on the horizon. The Editor has had occasion to publish a special description of a dust whirl with a beautiful delicate central column of vapor haze, a true incipient waterspout, forming on a hot afternoon over Pennsylvania avenue in Washington, D. C., and moving along for several minutes until broken up by the mixture of currents over the house tops.

In one of the bulletins published on the U. S. S. *Pensacola* in November, 1889, during the United States Eclipse Expedition to the west coast of Africa, he published some details as to the formation, growth, and dissipation of a series of twenty or thirty waterspouts among which that vessel sailed and into some of which it penetrated.

The latest illustration of the formation of local whirls and clouds is contained in a letter from Rev. G. M. Davis, Cedartown, Ga., dated March 15, 1905.

He stated that he "raked together a circle of dry leaves, fired them simultaneously on four sides, and noted that on two sides of the circle the fire was hotter where the pile of leaves was thicker." He then "noticed that a miniature whirlwind formed in the flame and smoke, continuing so long as the heat was greater on two sides and there was no fire in the center, while all distinguishable rotary motion ceased as soon as the heat became equable at all points." This observation suggests to him the following hypothesis with regard to hurricanes, namely, "that the interior of a circle 500 miles in diameter is filled with air of a certain temperature and surrounded by air of a higher temperature; that in this outer circle the two opposite sides are hotter than the remaining portion, and that the hot air streaming upward from these two special regions constitutes the source of the whirlwind."

This is one form of the many diversified hypotheses that have been offered, all of which taken together are known as the convectional theory. Considerable attention is given to these theories in the Editor's work known as "Preparatory Studies for Deductive Methods in Storm and Weather Predictions," Washington, 1880. Without experimenting with fire one may do even better by watching the movements of the steam and air above a horizontal surface of boiling water. (See page 29 of that work.) The rising vortex is by no means the only form of motion. However, all such theories seem not to be directly applicable to the origin of hurricanes, however well they may apply to the origin of tornadoes and thundershowers. In the case of the hurricane we have to deal with nearly horizontal motions; the ascending component is so slight that although it exists and is important yet it can not be thought of as causing the whirlwind. In so far as hurricanes have been traced back to their origin the daily weather maps simply show a large area of perhaps 10,000 square miles within which the winds are light and variable, and the temperature and moisture a little higher than on the outside. A strong current of wind suddenly appears pouring into this region—it may be a northerly wind on the west side or a southerly wind on the east side, an easterly wind on the north side or a westerly wind on the south side—and quickly the whole mass gets into motion, and the barometer falls in the central region.

Ferrel has shown that the fall in the barometer and the rotation of the whole mass is due to the diurnal rotation of the earth on its axis. A very slight barometric depression is sufficient to start a current of air in the direction of the gradient, and this wind then causes a great barometric gradient in a direction at right angles to it; so the isobars and gradients shown on our daily weather maps around every storm center are the result of the winds and the rotation of the earth. When once the rotation is started it would die away, on account of the resistances offered by the earth's surface, unless there were some maintaining cause, and two such causes have been discussed.

First. That one suggested by Espy, and especially worked out by Ferrel, namely, the heat evolved by the condensation of vapor into cloud and rain.

Second. The surplus energy derived from the underflow of the cold air from polar regions toward the equator, and the return of the equatorial air toward the pole, the importance of which has been especially insisted upon by Professor Bigelow.

These polar and equatorial currents may be superposed vertically or may flow on side by side laterally. In the former case they roll over and over each other where they meet, and form roll clouds, roll cumuli, roll cirrus, and bring sudden changes from warm to cold and from cold to warm, with a preliminary slight dash of rain. In the latter case they whirl around a central region with a grand sweep, with southerly winds on the east and northerly winds on the west side, in the Northern Hemisphere, and the whole system moves along over the surface of the globe day after day; there is usually heavy rain on the east side, and according to Ferrel this must contribute to the maintenance of the whirl.

These great whirls with low pressure at the center lie between much larger areas of high pressure, and are sometimes said to be fed by them. After they have moved northward beyond the influence of the high pressure of the North Temperate Zone and approach the Arctic Zone, they seem to die away, and we do not yet know enough about the storms north of 65° north latitude to say with certainty whether they are straight-line gales or hurricanes.

We have used the words "whirlwind," "hurricane," and "tornado" because there can be no doubt what is meant by these terms. The technical meteorologists would use the single word "cyclone," or "area of low barometer," or simply "low;" but we have avoided the use of the word "cyclone" because our correspondent, like many other writers and the whole newspaper fraternity, has applied the word "cyclone" specifically to tornadoes, which we think is very objectionable. Of course we recognize the fact that the English language is in a state of perpetual change and the usage of one century is sure to differ from that of the next, but it is not common in scientific literature to arbitrarily change the meaning of such a specific word as "tornado."

The word "cyclone" was devised as equivalent to a special theory as to how the wind moves in hurricanes on the ocean, and ought never to have been applied to a tornado. That erroneous usage began, so far as we know, with a popular sensational newspaper writer in 1875. Another similar writer endeavored to go him one better by introducing the French word *tourbillion* as being a little more high-sounding than the correct French word *tourbillon*. We could wish that this usage had survived, as it would have saved us the annoyance of the popular confusion of the terms "tornado" and "cyclone."—*C. A.*

A METHOD OF PREDICTING THE MOVEMENT OF TROPICAL CYCLONES.

By Mr. MAXWELL HALL. Dated Montego Bay, Jamaica, W. I.. February 19, 1906.

At the given time and place let p be the pressure, i. e., the reading of the barometer in inches and decimals of an inch, corrected for instrumental error, reduced to 32° F., sea level, and standard gravity, and further corrected for diurnal variation; let p_m be the mean value of p for the season; let $\Delta p = p_m - p$, so that Δp is the fall of pressure below the mean; and let r be the distance, in miles, between the observer and the nearest edge of the central calm area of the cyclone.

Let a line be drawn from the center through the place of observation to the outer limit of the cyclone; then along that line, and except when near the central calm, we have the equation—

$$\Delta p = \frac{c}{\sqrt{r - a}} \qquad (1)$$

a and c are constants along the line; and if a curve be drawn showing the relation between Δp and r it will be found that Δp leaves the curve at a certain point near the central calm, and then follows the tangent to the curve at that point until it reaches the calm.

This statement applies only to tropical cyclones; in higher latitudes other forces, such as the effect of the rotation of the earth, render equation (1) quite inapplicable.

Let us take as an example the Jamaica cyclone of August 11, 1903. The center moved in a remarkably straight line from Martinique to Jamaica, and on to the Cayman Islands, at the rate of 20 miles an hour, and as the edge of the central calm reached Montego Bay at 9:15 a. m., there is no difficulty in obtaining the different values of r given in the fifth column in Table 1. The different values of Δp were found by taking p_m to be 29.928.

TABLE 1.—*Montego Bay, August, 1903.*

Day and hour.	p	Δp	Wind.	r	Δp Computed.
	Inches.	*Inches.*	*M. p. h.*	*Miles.*	*Inches.*
10th, 6 p. m.	29.837	0.09	3	305	0.11
11th, 6 a. m.	29.686	.24	10	65	.24
11th, 7 a. m.	29.609	.32	20	45	.29
11th, 8 a. m.	29.520	.41	50	25	.39
11th, 8:15 a. m.	29.478	.45	60	20	.45
11th, 8:30 a. m.	29.427	.50	60 to 80	15	.52
11th, 8:45 a. m.	29.331	.60	60 to 80	10	.67
11th, 9 a. m.	29.16	.77	60 to 80	5	*0.77
11th, 9:15 a. m.	28.93	1.00	0	0	....

*Measured along the tangent to the curve.

In order to plot the curve showing the connection between Δp and r, take a scale of 40 divisions to an inch, let each division represent a mile along the horizontal line, and let each division represent 0.01 inch of Δp down the vertical line.

In fig. 1, Plate I, the dots surrounded by small circles show the observed values of Δp, while the curve is drawn among them with a free hand.

From the smooth curve we have,

r	Δp
80.........	0.22
60.........	0.25
40.........	0.32
20.........	0.45

and then from equation (1) we have, approximately,

$$a = +2$$
$$c = 1.9.$$

To solve the equations by the method of least squares would be a waste of time; the nature of the work permits only approximate values. From these values of a and c, Δp was computed, and the results given in the last column of Table 1.

The close agreement between the observed and computed values of Δp shows that equation (1) suits this particular cyclone.

It will be noticed that Δp leaves the curve when r is about 5, Δp about 0.77, and the wind blowing a hurricane. For values of r less than this, or even less than 10, equation (1) gives values of Δp absurdly large. The tangent is drawn through 1.05, the lowest pressure.

As a second example let us take the Jamaica cyclone of August 20, 1886. It passed centrally over Kingston, along a line joining Kingston and Montego Bay, at the rate of twelve miles an hour; but near Montego Bay it turned northward. (Jamaica Weather Report No. 69). The effects of the small, secondary cyclone near St. Anns Bay were entirely local; it did not perceptibly affect the barometer at either Kingston or Montego Bay. (See Table 2.)

The different values of Δp were found by taking p_m=29.914. The lull at the center lasted for about half an hour, from 3:30